Cosmic Masers - from OH to H_0
Proceedings IAU Symposium No. 287, 2012
R.S. Booth, E.M.L. Humphreys & W.H.T. Vlemmings, eds.

doi:10.1017/S1743921312007065

Preliminary results on SiO v=3 J=1–0 maser emission from AGB stars

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Abstract. We present the results of SiO maser observations at 43 GHz toward two AGB stars using the VLBA. Our preliminary results on the relative positions of the different J=1–0 SiO masers (v=1,2 and 3) indicate that the current ideas on SiO maser pumping could be wrong at some fundamental level. A deep revision of the SiO pumping models could be necessary.

Keywords. Maser, AGB stars

1. Introduction

Many stars have been mapped in SiO emission J=1–0 v=1 and 2, particularly using the VLBA (Diamond *et al.* 1994, Desmurs *et al.* 2000, Cotton *et al.* 2006, etc). The maser emission is found to form a ring of spots at a few stellar radii from the center of the star. In general, both distributions are similar, although the spots are very rarely coincident and the v=2 ring is slightly closer to the star (see e.g. Desmurs *et al.* 2000).

The similar distributions of the v=1, 2 J=1–0 transitions were first interpreted as favoring collisional pumping, because the radiative mechanisms tend to discriminate somewhat more strongly both states. But the lack of coincidence was used as an argument in favor of radiative pumping, leading to the well-known, long-lasting discrepancy in the interpretation of the v=1, 2 J=1–0 maps in terms of pumping mechanisms (see discussion in e.g. Desmurs *et al.* 2000).

The discussion on this topic has dramatically changed when the first comparisons between the v=1 J=1–0 and J=2–1 maser distributions were performed (see Soria-Ruiz *et al.* 2004, 2005, 2007). In contradiction with predictions, from both radiative and collisional models, the v=1 J=2–1 maser spots systematically occupy a ring with a significantly larger radius (≈30%) than that of v=1 J=1–0, both spot distributions being completely unrelated. Soria-Ruiz *et al.* (2004) interpreted these unexpected results invoking line overlap between the ro-vibrational transitions v=1 J=0 – v=2 J=1 of SiO and ν_2=0 $J_{k_a k_c}$=12 $_{7,5}$ – ν_2=1 $J_{k_a k_c}$=11$_{6,6}$ of H_2O. This phenomenon would also introduce a strong coupling of the v=1 and v=2 J=1–0 line, explaining their similar distribution.

If our present theoretical ideas are correct (e.g. Bujarrabal & Nguyen-Q-Rieu 1981, Bujarrabal 1994, Locket & Elitzur 1992, Humphreys *et al.* 2002), the v=3 J=1–0 emission should require completely different excitation conditions than the other less excited lines. No pair of overlapping lines is expected to couple the v=3 J=1–0 inversion with any of the other SiO lines. The v=3 J=1–0 spatial distribution should be different compared to the J=1–0 v=1, 2 ones and, of course, of the J=2–1 v=1 maser, and placed in a still smaller ring than v=2.

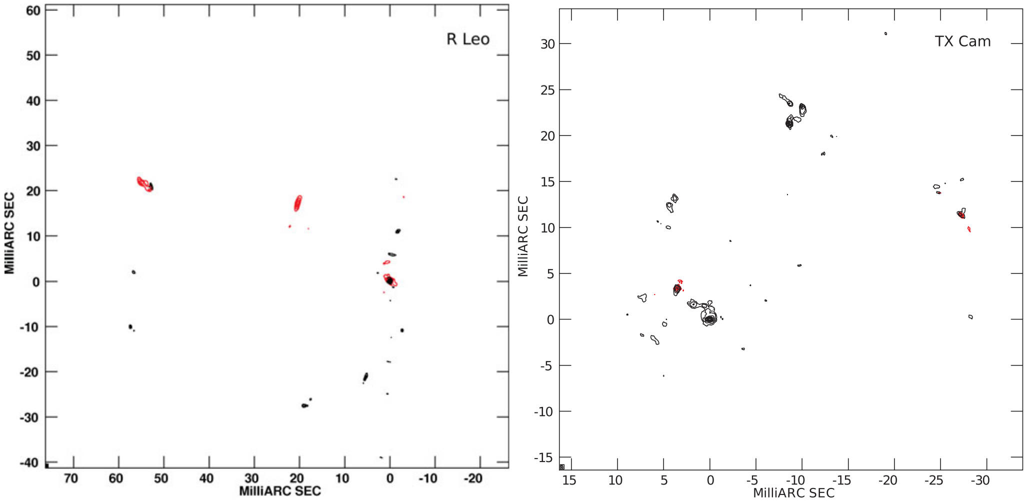

Figure 1. VLBA map of SiO J=1–0 v=2 (in black) and v=3 (in red) maser emission from R Leo (right) and TX Cam (left)

2. Preliminary results toward R Leo and TX Cam

The v=3 J=1–0 line is sometimes quite intense (Alcolea *et al.* 1989), and bright enough to be mapped with the VLBA, but it is strongly variable, both in time (with characteristic times scales of a few months) and from object to object. With the 20-m antenna of Onsala, we monitored a number of AGB stars to select the best candidates to be mapped with the VLBA, observing simultaneously the v=1,2 and 3 J=1–0 SiO masers at 42-43 GHz.

In the figure above, we show a preliminary map of the brightness distribution of ^{28}SiO v=2 and 3, J=1–0 obtained toward R Leo (on the left) and TX Cam (on the right). These are the first VLBA maps ever of the v=3 J=1–0 maser (in red). Although the alignment between the maps of the two lines is just indicative (the observations were not done in phase referencing mode, and the proposed alignment is based on the similarity in velocity and the spatial distribution of some spots).

These preliminary results show a surprising similar distribution in the v=3 J=1–0 and v=1, 2 J=1–0 masers. Would this result be confirmed, our ideas on SiO maser pumping scheme must be wrong at some fundamental level and a deep revision of the SiO pumping models will be necessary.

References

Alcolea, J., Bujarrabal, V., & Gallego, J. D., 1989, *A&A* 211, 187
Bujarrabal, V. & Nguyen-Q-Rieu, 1981, *A&A* 102, 65
Bujarrabal, V., 1994, *A&A* 285, 953
Cotton, W. D., Vlemmings, W., Mennesson, B. *et al.*, 2006, *A&A* 456, 339
Desmurs J.-F., Bujarrabal V., Colomer F., & Alcolea J., 2000, *A&A* 360, 189
Diamond P. J., Kemball A. J., Junor W. *et al.*, 1994, *ApJ* 430, L61
Humphreys, E. M. L., Gray, M. D., Yates, J. A. *et al.*, 2002, *A&A* 386, 256
Lockett P. & Elitzur M., 1992, *ApJ* 399, 704
Soria-Ruiz, R., Alcolea, J., Colomer, F. *et al.*, 2004, *A&A* 426, 131
Soria-Ruiz, R., Colomer, F., Alcolea, J. *et al.*, 2005, *A&A* 432, L39
Soria-Ruiz, R., Colomer, F., Alcolea, J. *et al.*, 2007, *A&A* 468, L1

https://doi.org/10.1017/S1743921312007065 Published online by Cambridge University Press